# *Dermatophagoides farinae*: The Supracoxal Glands[1]

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**Abstract:** The structure and possible function of the supracoxal glands of the house-dust mite, *Dermatophagoides farinae*, have been described. Light and electron microscopical techniques were used to study this extremely complex gland. There is one pair of supracoxal glands in the house-dust mite. Each gland is composed of eight cells that make up four two-celled functional units. Three of the two-celled units are similar to each other, whereas the fourth unit is smaller with a distinctly different morphology. The cells of the glands are characterized by several criteria, but common to all are numerous mitochondria, infolded cell membranes, microtubules, and a cuticle-lined duct. The ducts of all the functional units have a point of common attachment from which an anteriorly directed duct goes to the outside. Repugnatorial and osmoregulatory functions are discussed.

The coxal glands of several species of mites and ticks have been studied at the level of resolution of the light microscope (e.g. Grandjean, 1937a, 1937b; Lees, 1946; Moss, 1962; Prasse, 1967; Woodring, 1972). With the additional aid of scanning and transmission electron microscopy it is now possible to report on the structure of the supracoxal glands in *D. farinae* Hughes, 1961.

Previous studies on anatomical details of *D. farinae* have considered the lateral opisthosomal dermal glands (Brody and Wharton, 1970) and the digestive system (Wharton and Brody, 1972; Brody, *et al.*, 1972). The dermal glands and the digestive system are two sites of production for materials which are deposited in house-dust by *D. farinae*. The house-dust mite has been implicated as a source of allergen by a number of investigators (see van Bronswijk and Sinha, 1971, for a literature review), and secretions of the supracoxal glands may play a role in this situation.

## MATERIALS AND METHODS

Mites cultured in the Acarology Laboratory were used in this study. Whole mounts were observed by phase contrast light microscopy and scanning electron microscopy, and sections were observed by bright field light microscopy and transmission electron microscopy. All specimens were prepared according to procedures described in Brody *et al.*, 1972.

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## RESULTS

Dorsal to coxa I of the house-dust mite are sclerotized plates designated as supracoxal sclerites (Fig. 1). Each sclerite has a fossa (Grandjean, 1937a) which is circumscribed by a heavy cuticular ridge (Fig. 2). In the center of the fossa are three obliquely directed cuticular folds which hide the external orifice of the supracoxal gland (Fig. 3). The orifice is actually a slit-like opening which is surrounded by an internal sclerotized ring (Fig. 3). A medially directed extension of the supracoxal fossa is covered by a dorsal cuticular flap that forms the margin of the sclerite (Fig. 2). This extension of the fossa covers a narrow channel that progresses medially, ventrally, and anteriorly, over the dorsal aspect of the palpal coxa to ultimately communicate with the pre-buccal cavity (Fig. 2). Within the limits of the heavy cuticular ridge and ventral to the oblique folds is a gutter-like groove which runs ventrally and medially from the supracoxal sclerite to the region between the coxa of leg I and the gnathosoma (Figs. 2 & 4). This groove does not communicate with the pre-buccal cavity. Ventral to the groove and the oblique folds on the sclerite is the spike-like supracoxal seta of leg I. The base of the seta originates from beneath a cuticular flap and the tip points ventromedially (Fig. 4).

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Fig. 1. Scanning Electron Micrograph (SEM) of a female North American House-Dust mite *Dermatophagoides farinae*. The supracoxal sclerites (arrowheads) are situated between the coxae of leg I (C) and the gnathosoma (G). × 500.

Fig. 2. A closer view of the supracoxal sclerite by SEM demonstrates the heavy cuticular ridge (R) dorsal to the sclerite and three cuticular folds (small arrowhead) within the supracoxal fossa. An extension of the ridge (arrow) covers a channel which goes dorsally over the rim of the palpal coxa (PC). A gutter-like grove (double arrowhead) runs between the coxa of leg I (C) and the ventral gnathosoma. × 5000.

Fig. 3. Light photomicrograph of the sclerotized ring (arrowhead) which surrounds the orifice of the supracoxal gland. × 800.

Fig. 4. The SEM provides a postero-lateral view of the supracoxal fossa (F), the dorsal cuticular ridge (R), and the ventral gutter-like groove (arrowhead). The supracoxal seta (S) of leg I is directed anteromedially. × 2000.

Fig. 5. Diagrammatic representation of the dorsal functional unit of the supracoxal gland. The peripheral cytoplasm of cell type A (A) has numerous fimbria (arrow). Cell type A surrounds one end of the duct (D) and all of cell type B (B). Cell type B envelops most of the duct. Nucleus (N).

Fig. 6. A medial view of the three similar functional units. The fimbriated portions (arrow) of the ventral cell extend laterally into the coxa of leg I. The type A cells (A) surround the type B cells (B). The fimbria of the dorsal unit form the most dorsal aspect of the supracoxal gland. The medial unit is designated by arrowheads. Nuclei (N).


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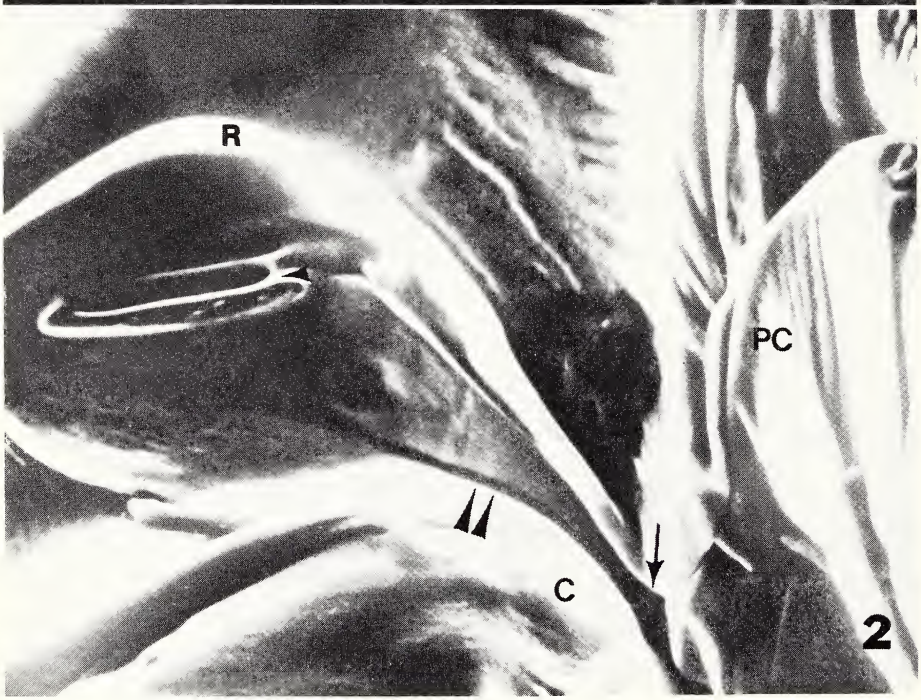
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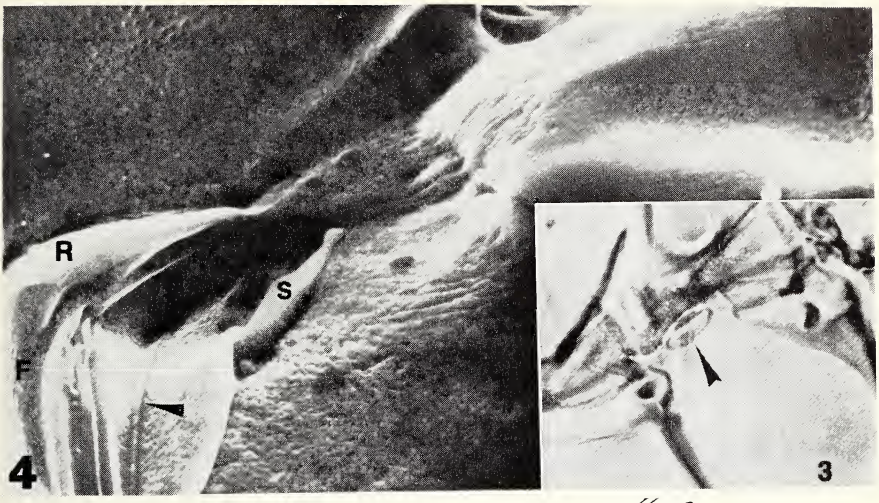
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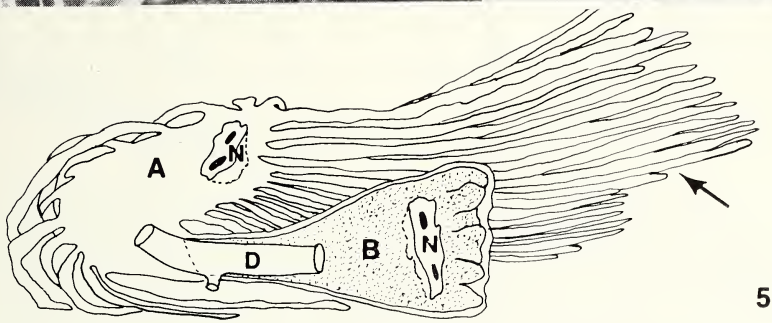
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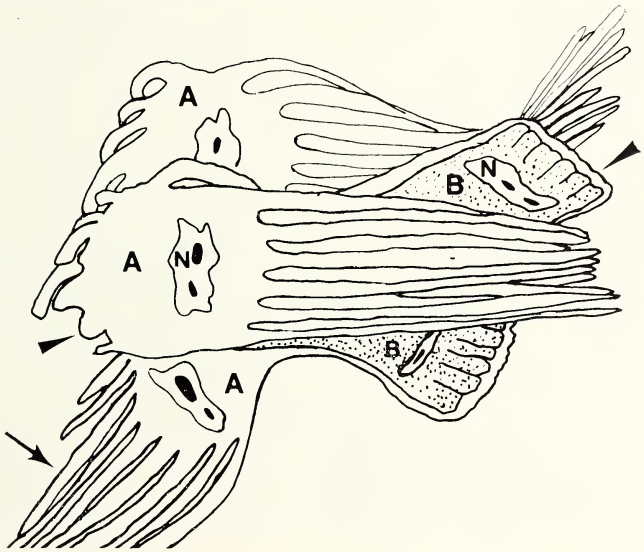
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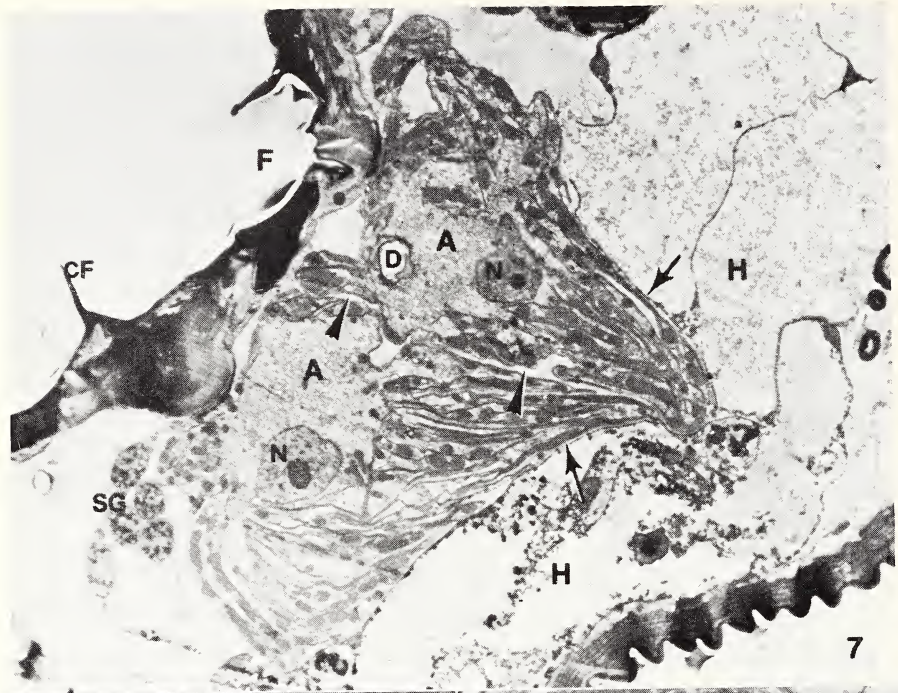
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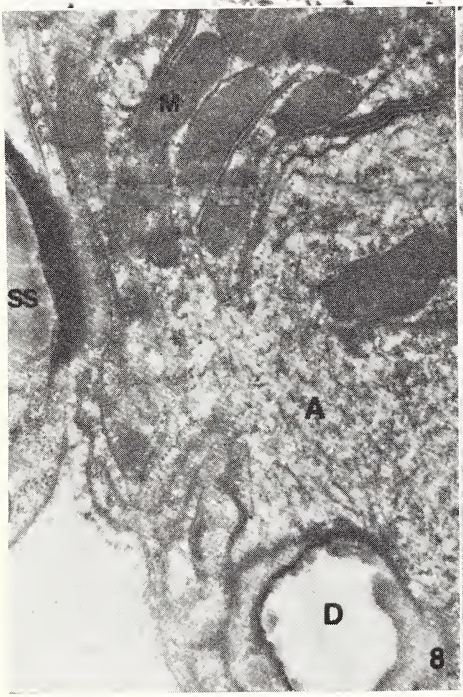
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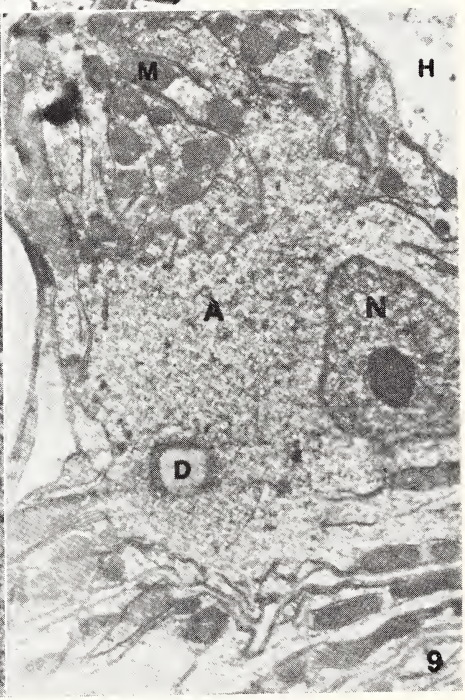
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There is one pair of supracoxal glands in the house-dust mite. Each gland has an overall dimension of about 35 microns in dorsal-ventral aspect and approximately 70 microns in anterior-posterior aspect. The glands are located posterior to the supracoxal sclerite, anteriorly and laterally within the propodosoma, and each gland has its single external orifice dorsal to the coxa of leg I (Fig. 2), within the fossa of the supracoxal sclerite.

Each gland is composed of eight cells that make up four two-celled functional units each with a cuticle-lined duct (Fig. 5). Three of the two-celled units are similar to each other (Fig. 6). The fourth unit is smaller with a distinctly different morphology (Figs. 18 & 19).

The three similar units (Fig. 6) have the largest cell of the unit named the type A cell. This type is characterized by a cell body that contains the nucleus and by great numbers of folded membranes that are thrown out into cell processes (Fig. 7). Numerous mitochondria are lined up along the membranes (Figs. 7 & 8). Thus, most of the periphery of the A cell is made up of folded membranes and adjacent mitochondria. The cytoplasm of the cell body is highly granular internal to the peripheral mitochondria (Fig. 9), and there are no recognizable organelles other than the single distinct nucleus (Figs. 7 & 9) and a few microtubules with no particular orientation (Figs. 8 & 9).

The type A cell envelops the second cell type, or type B cell, of the functional unit (Figs. 5 & 6). The type B cell (Fig. 10) is also characterized by folded membranes though they do not form the elongated processes which typify the type A cell. Numerous peripheral mitochondria are associated with the membranes of the B cell (Fig. 11). The internal cytoplasm contains a single nucleus, and is replete with microtubules which are directed along the long axis of the cell (Fig. 12). The type B cell also contains a cuticle-lined duct which is oriented in the same direction as the microtubules (Figs. 8 & 10). The mitochondria of the type B cell are similar in appearance to those of the

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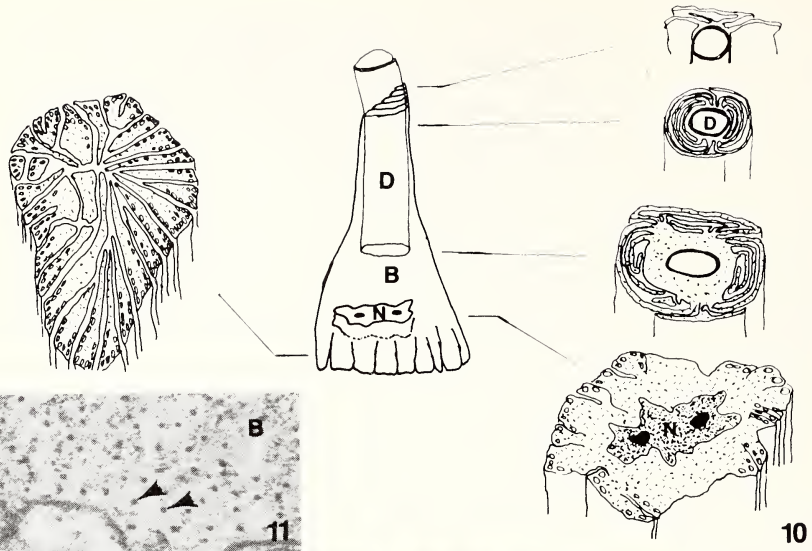
Fig. 7. Transmission electron micrograph (TEM) of a cross-section through the dorsal and medial functional units. This section has revealed a duct (D) within the cytoplasm of one type A cell (A). Fimbriated portions (arrows) of the type A cells, with numerous mitochondria, are adjacent to the haemocoel (H). Cuticular folds (CF) are within the supracoxal fossa (F) and a portion of a multinucleated salivary gland (SG) lies medial to the supracoxal gland. Nuclei (N) of the type A cells are obvious as is the intercellular space (arrowheads) of the two type A cells. × 1500.

Fig. 8. A higher magnification of the cuticle-lined duct (D) within a type A cell (A). The A cell, with its peripheral mitochondria (M), is posterior to the supracoxal sclerite (SS). × 5000.

Fig. 9. The end of the duct (D) within the type A cell (A) is capped. The nucleus (N) is obvious, and peripheral mitochondria (M) within the fimbria are seen. × 2500.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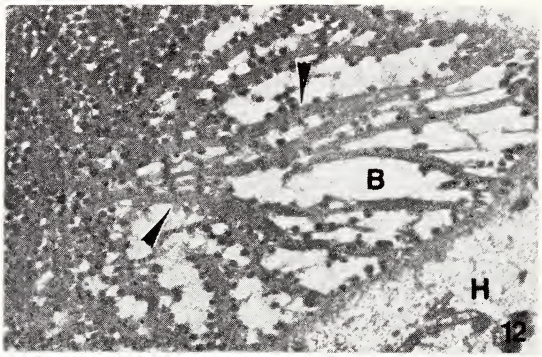
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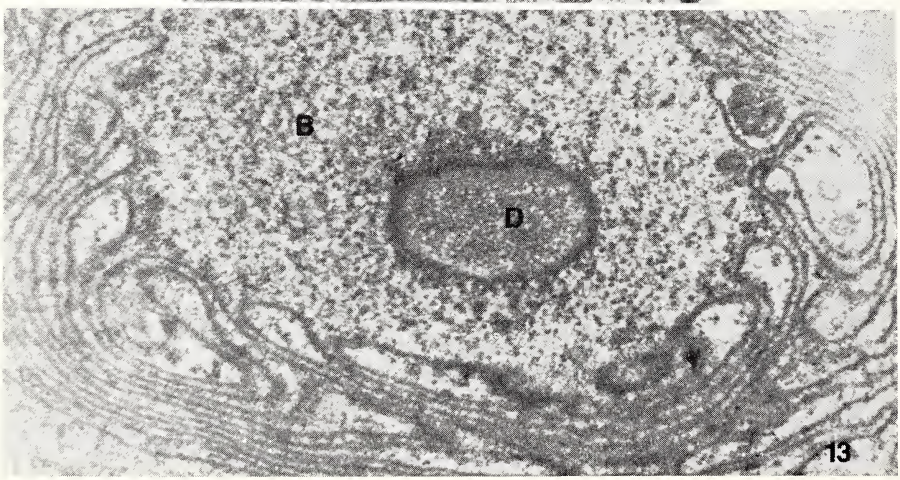
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type A cell, but are usually one-half to two-thirds the size of the latter. The diameter of the microtubules is approximately 500 Å. The diameter of the duct lumen is about 3.5 microns, and the thickness of its cuticular wall is approximately .20 microns. That portion of the type B cytoplasm which surrounds the duct is thrown into concentric swirls of membranes (Figs. 10 & 13). These remarkable swirls become more densely packed toward the end of the duct which is closest to the type A cell (Figs. 10 & 14). Consequently, there is very little type B cytoplasm at this end of the duct, while the granular type A cytoplasm is quite obvious (Figs. 8 & 10). Furthermore, close to this region, the anterior (nucleated) portions of the type A cells fold back upon themselves so that cross-sections through the supracoxal glands reveal cytoplasm of both the type A and type B cells, including the ducts (Figs. 6 & 15).

A fourth pair of cells forms a unit unlike that composed of cell types A and B. This fourth pair includes a secretion unit, or type C cell, that is characterized by its comparatively small size (approximately 12 microns long by 8 microns wide) and its cytoplasm which is replete with a variety of organelles (Fig. 16). The most easily recognized components of the type C cell are the extensive rough endoplasmic reticulum, lysosomes, mitochondria, and single nucleus. However, in the more dorsal aspect of this cell type are numerous vesicles which are bound by basement membrane-like structures and have the appearance of empty cisterns (Fig. 17). A cuticle-lined duct which is a narrow (.50 microns diameter) sinuous tube is found within the duct-producing cell that accompanies the type C cell. This duct-producing, or type D, cell has at least one nucleus and several mitochondria in close proximity to the duct itself (Fig. 18).

The four ducts of the functional units have a point of common attachment from which an anteriorly directed duct passes through the supracoxal sclerite to the outside (Fig. 19). The ducts of the three similar units are wholly contained within the type B cells except for the ends closest to the type A cell.

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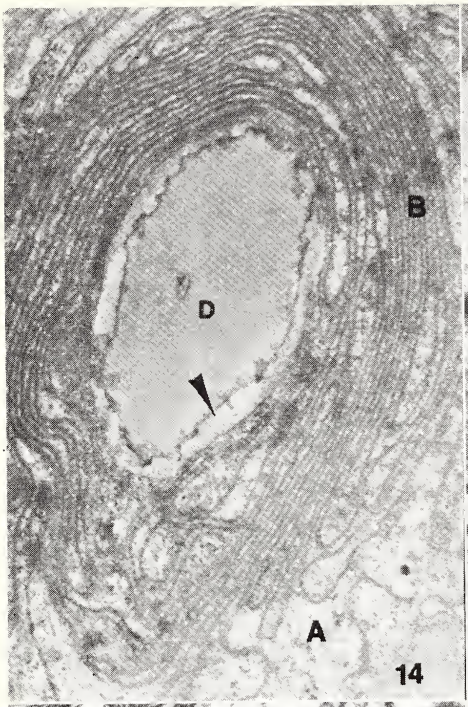
Fig. 10. A diagram of the type B cell (B) with its duct (D). The schematic cross-sections indicate that the cytoplasm is thrown into swirls around the duct, whereas the type B cytoplasm below the duct is highly infolded and contains many peripheral mitochondria. Nucleus (N).

Fig. 11. The cytoplasm of the type B cell (B) is replete with microtubules (arrowheads), many of which are directed along the long axis of the cell. × 9000.

Fig. 12. TEM of a section near the base of the type B cell (B). Numerous infolded membranes and mitochondria (arrowheads) are obvious. Haemocoel (H). × 3500.

Fig. 13. The end of the duct (D) within the type B cell (B) appears to be covered by a porous cap. The peripheral cytoplasm is in swirls. × 7500.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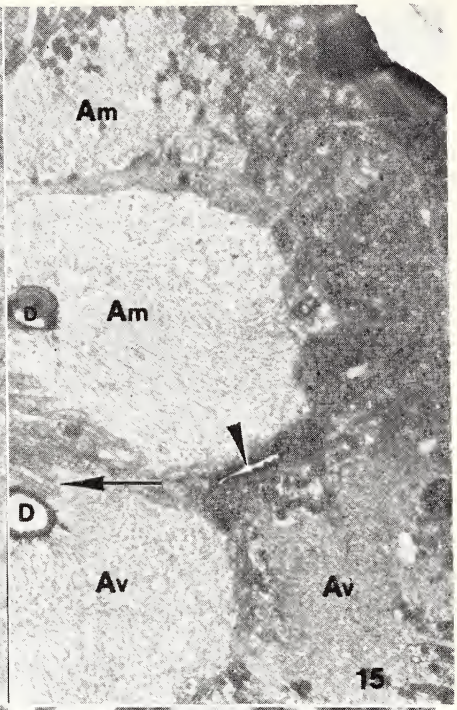
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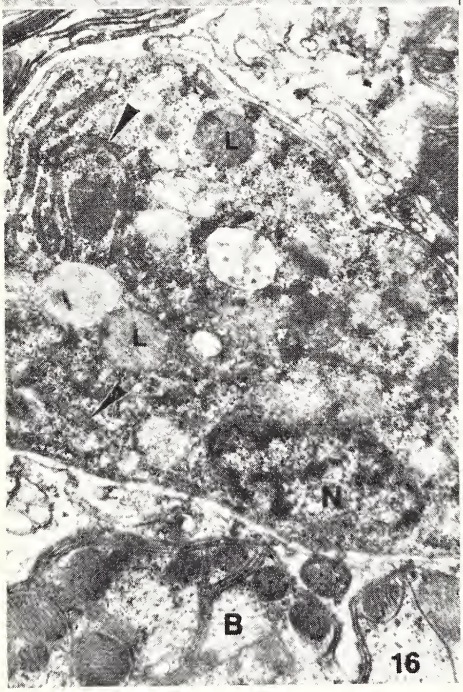
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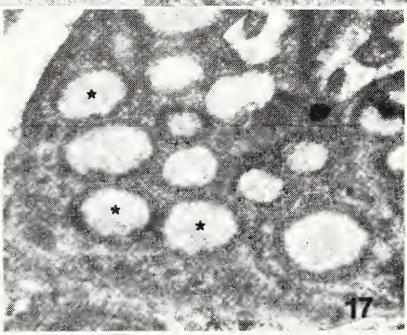
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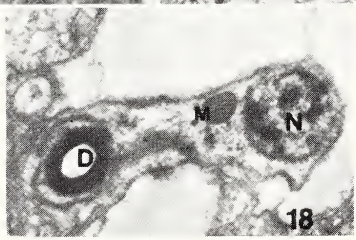
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These duct ends appear as porous caps which communicate with the cytoplasm of the type A cell (Figs. 7, 8 & 15). The opposite end of the duct has an identical porous cap within the cytoplasm of the type B cell (Fig. 13).

Following a description of the components of the supracoxal gland, it is now possible to place these components in their relative spatial positions within the mite. The three similar units are approximately the same size. There is one unit dorsally, one in the middle, and one ventrally, with the type C cell located laterally (Figs. 6 & 19). The dorsal unit is situated so that its cell body is medial to the cell body of the middle unit, but its posterior limit is the most dorsal element of the supracoxal gland (Fig. 6). The portion of the type A cell which folds back upon itself extends in a dorso-medial direction (Fig. 5). The middle unit is also the most lateral of the three and its cell body (of the type A cell) is folded dorsally (Fig. 6). The ventral unit has the cell body of its type A cell directed ventro-laterally so that a part of it protrudes into the coxa of leg I (Figs. 20 & 21).

## DISCUSSION

The supracoxal glands of acarid mites have been ascribed several functions such as respiratory (Megnin, 1886), salivary (Lonnfors, 1930), and accessory (Woodring, 1972). This is not surprising when one considers the great morphological variety and diversity of habitat which are encountered among the

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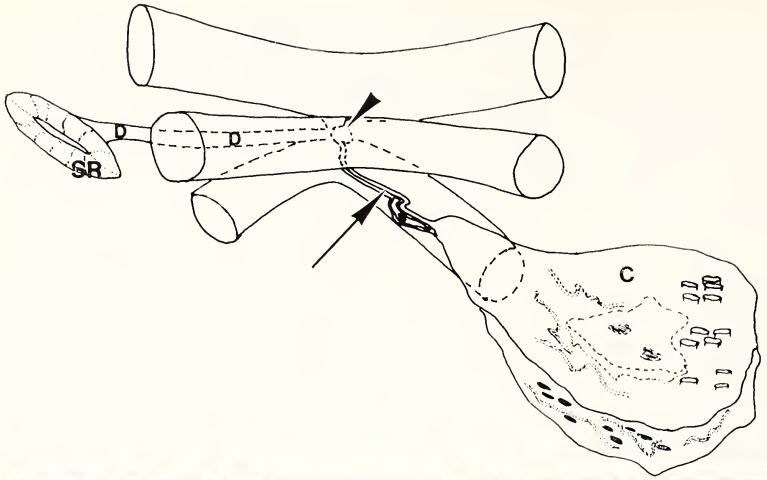
Fig. 14. A cross-section through the middle of the duct (D) demonstrates the remarkable swirls of type B cytoplasm (B) and membranes which surround the duct. The duct is lined by cuticle (arrowhead), and type A (A) cytoplasm envelops the complex. × 7500.

Fig. 15. A cross-section through anterior portions of the medial (Am) and ventral (Av) units of the supracoxal gland reveals the region where the type A cells fold back upon themselves; thus we observe the ducts (D) surrounded mostly by type A cytoplasm (see Fig. 5). One duct is in contact with a few swirls of the type B cell (arrow), and the other duct is partially covered by its porous cap, so no type B cell is apparent. The lateral, external cuticle of the mite is seen in the upper right hand corner of the picture. Also observed at this level is a portion of the narrow duct (arrowhead) which leads to the fourth functional unit. × 3000.

Fig. 16. The secretory cell (type C cell) of the fourth functional unit is characterized by a single nucleus (N), lysosomes (L), and an extensive rough endoplasmic reticulum (arrowheads). The base of a type B cell (B) is nearby. × 9500.

Fig. 17. Portions of the secretory cell seen in Fig. 16 are characterized by apparently empty cisterns (*) surrounded by thick walls. × 9500.

Fig. 18. A narrow, winding duct (D), with its own duct-producing cell (N = nucleus, M = mitochondrion), leads from the secretory cell (type C cell) of the fourth functional unit to a common union with the other ducts (see Fig. 19). × 9500.

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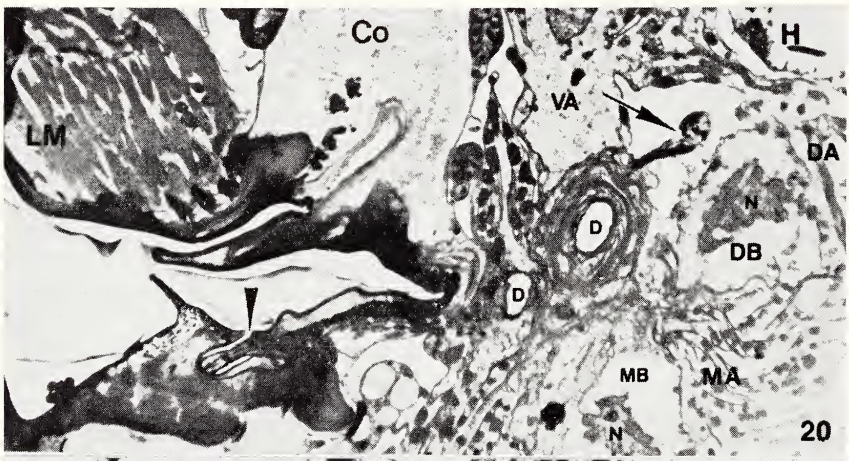


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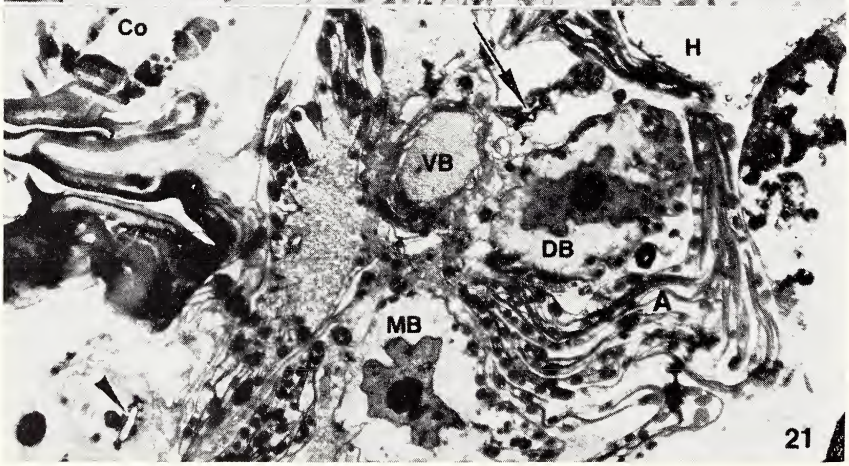


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families of the Acaridei (Acaridia). Thus it is difficult to dismiss any proposed function as impossible.

In the case of *D. farinae*, the supracoxal glands have structural details which are suggestive of a repugnatorial apparatus fashioned after that of several arthropods (Eisner, 1970). These arthropods have reactor glands in which chemical precursors are produced so they can be mixed and subsequently catalyzed at the moment of discharge. The supracoxal glands of *D. farinae* may be constructed to perform in this manner. In each functional unit of the supracoxal gland, two cell types have access to a cuticle-lined duct. (The presence of cuticular ducts is probably a necessity when dealing with potentially noxious products.) Cell type A, with its many mitochondria adjacent to the haemocoel, may concentrate materials from the haemolymph to be secreted in some form through the porous end of the duct (Fig. 9). Cell type B functions as a duct-producing cell and possibly is secretory as well. It is essential to recall that the type C cell communicates with the other cell types at the point of common attachment for the ducts. The type C cell is replete with rough endoplasmic reticulum which may indicate the synthesis of a proteinaceous product, possibly an enzyme. Therefore, if the type B cell has a secretory function, it could secrete its product through the porous cap and

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Fig. 19. A diagrammatic representation of the ducts with the cytoplasm of the three similar units removed. The fourth functional unit (type C cell and duct) is enlarged and pulled laterally out of its normal position between the dorsal and ventral units. All the ducts, including the small narrow duct of the fourth unit (arrow), meet at a common point (arrowhead). An additional duct (D) passes through the cuticle of the supracoxal sclerite to open to the outside through a slit-like orifice surrounded by a sclerotized ring (SR) (see Fig. 3).

Fig. 20. A low magnification TEM of an antero-frontal section through the entire supracoxal gland. At this level, portions of all functional units are observed. To the right of the picture are the fimbriated portions of the type A cells from the dorsal (DA) and medial (MA) units. The nucleated (N) regions of the type B cells are also seen (Dorsal B cell = DB, Medial B cell = MB). The third similar functional unit is sectioned through the level of the duct (D) which is bent (see Fig. 19) so that two of its regions are viewed. This is in the ventral unit which has a portion of its A cell (VA) extending laterally into the coxa of leg I (Co) where leg muscles (LM) are seen. The small duct-producing cell of the fourth unit (arrow) is seen in its usual position between the dorsal and ventral units. An arrowhead marks the external opening of the channel which carries salivary secretions to the buccal cavity (see Fig. 2). Haemocoel (H). × 1500.

Fig. 21. A section ventral to that seen in Fig. 20. All anatomical features are the same except that we are now beyond the level of the ducts, and the swirled cytoplasm of the ventral type B cell (VB) is obvious. The duct (arrow) leading to the type C cell is observed, and the duct of a medial salivary gland (arrowhead) is also seen. Haemocoel (H). × 1500.

into the duct (Fig. 13) to mix with the product of the type A cell, whereupon the two secretions may be catalyzed by an enzyme from the type C cell prior to being discharged to the outside. If the type B cell is strictly a duct-producing cell, then an enzyme from the type C cell may be necessary to dissociate the secretion product (a process described in some arthropods by Eisner, 1970) of the type A cell into some repugnatorial agent. The biochemical and behavioral evidence to support this repugnatorial theory is not clearly available (Wharton & Arlian, 1972).

Several authors (Grandjean, 1937; Hughes, 1959; Hammen, 1968, Prasse, 1968; Woodring, 1972) have described the podocephalic canals of a few acariform mites. This canal is described as a gutter which passes medially and ventrally from the supracoxal sclerite over the dorsal aspects of the palpal coxae to the posterior limits of the pre-buccal cavity. Secretions from salivary glands located within the idiosoma are reportedly dumped into the podocephalic canals to be used pre-orally. Grandjean (1937) describes openings medial to the orifice of the supracoxal glands in an acarid mite, *Otodectes cynotis*. In *D. farinae*, idiosomal salivary glands which release their products into the podocephalic canal have been demonstrated (Brody *et al.*, 1972). This portion of the podocephalic canal is covered by a cuticular flap (Fig. 2) and the salivary duct makes its communication with the podocephalic canal at least 25 microns medial and ventral to the supracoxal gland orifice. In addition to this covered podocephalic canal, there is an open gutter on the supracoxal sclerite of *D. farinae* (Fig. 2), but it is ventral to the gland orifice and appears to merely run along the medial surface of coxa I (Figs. 2 & 4). It is possible that this gutter has been mistaken for the podocephalic canal by some authors.

As an alternative to the repugnatorial function described above, the complex supracoxal glands may be involved in an osmoregulatory process. Several investigators (e.g. Oschman and Wall, 1969) have studied the fine structure of various insect hindguts. The hindgut epithelium, reportedly an integral part of the insect's water balance mechanism, is composed in part of infolded cell membranes with numerous adjacent mitochondria. Electron micrographs of this insect system are strongly reminiscent of structures observed in the periphery of the type A and B cells in the supracoxal glands of *D. farinae* (Figs. 6 & 10). In addition, Woodring (1972) has made a strong case for an osmoregulatory function in the coxal glands of oribatid mites. The fine structural anatomy of oribatid coxal glands has not yet been described. However, consideration of Woodring's suggestion that the coxal glands of all mites are homologous at least in part, along with consideration of structural similarities between the supracoxal glands (of *D. farinae*) and the insect osmoregulatory apparatus, hopefully will stimulate the question of supracoxal gland function into further investigation.

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